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14. ABSTRACT
An examination of the scale interactions in predictability experiments is made using the NCAR Community Climate Model Version 3 (CCM3) at various horizontal resolutions ranging from T42 to T170. Both identical-model and imperfect-model twin experiments are analyzed, and they show distinctive differences from the classical inverse cascade picture of predictability error growth. IN the identical-model twin framework, error growth experiments using initial errors confined to long and short scales are compared and contrasted. In these cases, error growth eventually asymptotes to an exponential growth of baroclinically active scales. In the imperfect-model twin experiments, errors rapidly disperse from scales technically beyond model resolution to a small amplitude, spectrally uniform distribution of errors in resolved scales. The errors in resolved scales further amplify in a quasi-exponential growth of the baroclinically active scales. Finally, the implications of these growth mechanisms for the necessary resolution in short- to medium-range numerical weather prediction are given under the assumption that the accuracy of current initial state

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Determination of Mesoscale Predictability Limits with Respect to Uncertainty in the Larger-Scale Environment

A Final Report to
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Final Report:The Influence of Uncertainty in the Large Scale Environment on the Determination of Mesoscale Predictability Limits

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March 31, 2004

Over the past year we have concentrated our efforts on the publication of the perturbation methodology and the scale interaction aspects of our proposal. These publications included 1) a study of the intrinsic nature of predictability error growth 2) an analysis of the scale interactions associated with band-limited error and the cascade of error growth and 3) a study of perturbation sensitivity in ensemble prediction.

1 Intrinsic Predictability

Under item 1 (preprint attached) we described several facets of forecast error due to the subsequent growth of errors in the initial conditions of numerical weather prediction models. Specific results demonstrated that errors grow most rapidly in baroclinicly active regions and that the horizontal scale of errors increases with time. There is strong dependence in the rates of growth and the limits of forecast utility on the field considered and the nature of the initial error. The doubling time for 500hPa height errors is on average 1.5 days and the limit of skill for this field is typically 8-10 days given the current amplitude of errors in operational analyses.

2 Scale Interactions

In 2 an examination of the scale interactions in predictability experiments was made using the NCAR CCM3 at various horizontal resolutions ranging from T42 to t170. Both identical model twin and imperfect model twin experiments were analyzed and they showed distinctive differences from the classical inverse cascade picture of predictability error growth. In the identical model twin framework error growth experiments using initial errors confined to long and short scales were compared and contrasted. In these cases, error growth eventually asymptoted to an exponential growth of baroclinically active scales. In the imperfect model twin experiments, errors rapidly dispersed from scales technically beyond model resolution to a small amplitude, spectrally uniform distribution of errors in resolved scales. The errors in resolved scales were seen to further amplify in a quasi-exponential growth of the baroclinically active scales. Finally, the implications of these growth mechanisms for the necessary resolution in short to medium range numerical weather prediction was given under the assumption that the accuracy of current initial state estimates of the atmosphere remained fixed at their present level. This paper has appeared in Monthly Weather Review and the reprint is attached.

3 Perturbation Sensitivity

The third item which we have examined is the sensitivity of estimates of predictability error growth to different perturbation techniques in an ensemble forecast system. The questions addressed examine the structural differences between various perturbation schemes (bred vector, singular vector and random synthetic methods), their relationship to analysis errors, the differences in evolution of these errors as a function of time and space, and the development of mutually coherent patterns of error variance shared across these methods. In our examination of these questions we found that despite significant differences between the

three techniques in both the spatial structure and growth rate of perturbations over the first 3 days, beyond 3 days there exists a strong coherence in the variance patterns and growth exhibited by the three methods. This manuscript is in the final stages of preparation and will be submitted to Monthly Weather Review.

4 Future Plans

In the next year we will continue the publication of research funded under this grant, in particular research related to the refinement of the stochastic initial error simulator used in our ensemble experiments.

5 Additional Activity

In addition to the 3 prepared publications and 2 in preparation, we have given annual oral presentations of the research related to this project at both the annual DRI team meetings and at the AMS, AGU and EGS sessions associated with the DRI.

Oral Presentations, Invited

' Multi-Resolution Predictability Investigations' AGU, San Francisco CA, December 2000.

'Nonlinear problems in atmospheric predictability' invited talk, AGU, Boston, June 2001.

'Towards nonlinear probabilistic prediction' AMS Annual meeting, January 2002.

'Causes and models of model error' Joint EGS AGU meeting, Nice, April 2003